# Scenario Modelling: A Holistic Environmental and Energy Management Technique for Building Managers

James O'Donnell, Vladimir Bazjanac and Marcus Keane





## **Paper Outline**

**Domain Review with Case Studies** 

Proposed Solution: Scenario Modelling

**Demonstration** 

Conclusion

**Future Work** 

## **Key Domain Weaknesses**

- Operation requires reliable information.
  - Current Solution: Organisations employ experts
- Current analysis techniques
  - Fail to account for the unique nature of buildings
  - Fail to provide a complete reference
- Absence of standards that regulate Energy Performance Practices during building operation.
  - Europe: EPBD, ESD
  - US
  - Global: ISO 50001

Motivation Research Question Proposed Solution Demonstration Conclusions Future Work

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## **Key Domain Weaknesses**

- Manual transformation of available data
  - Subjective
  - Ad-hoc due to absence of standardised rule based data transformations and presentation formats
  - Absence of structured and standardised process, aided by appropriate tools
  - Not reproducible

## **Domain Review: Case Studies**

## **Categories**

**External Drivers** 

**Internal Drivers** 

Role

Data

Information

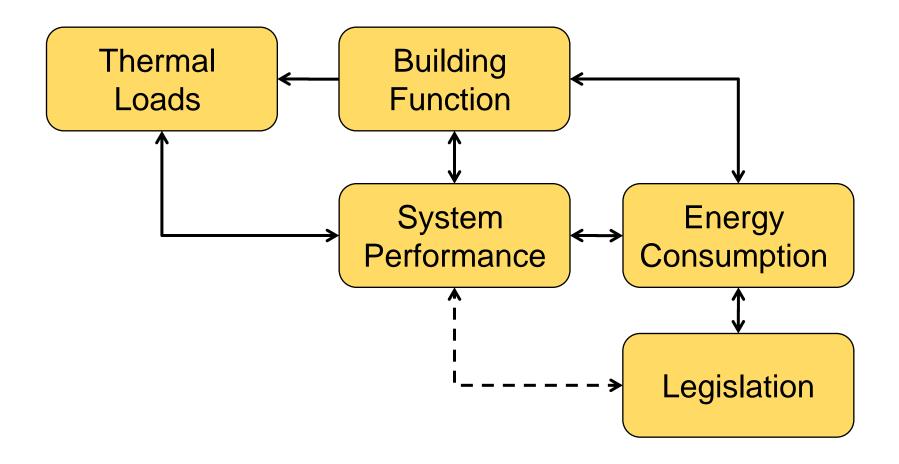
Tools

Techniques

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## Requirements for Holistic Analysis



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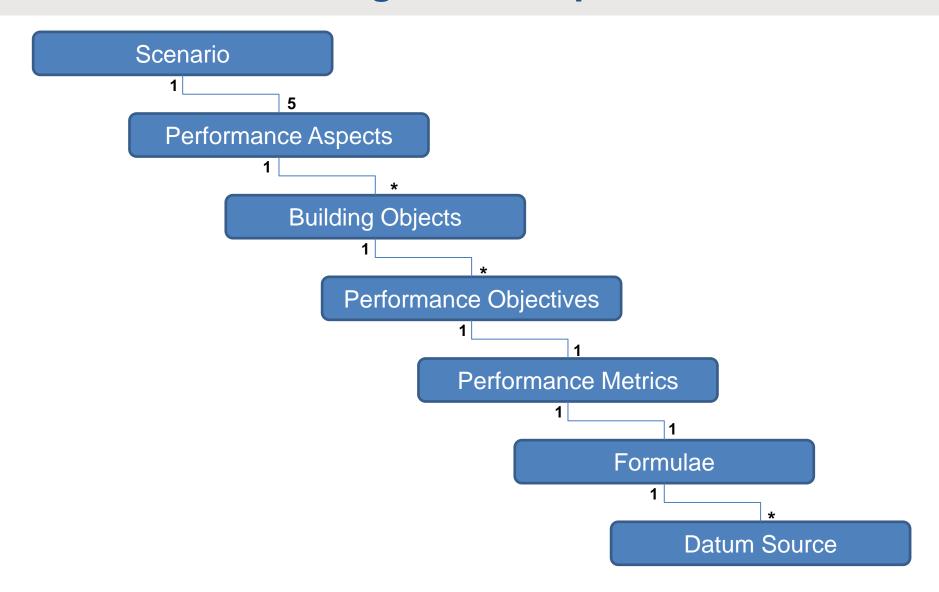
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## **Research Question**

What is the optimal format for presentation of holistic building performance information to building managers?

## Scenario Modelling Technique

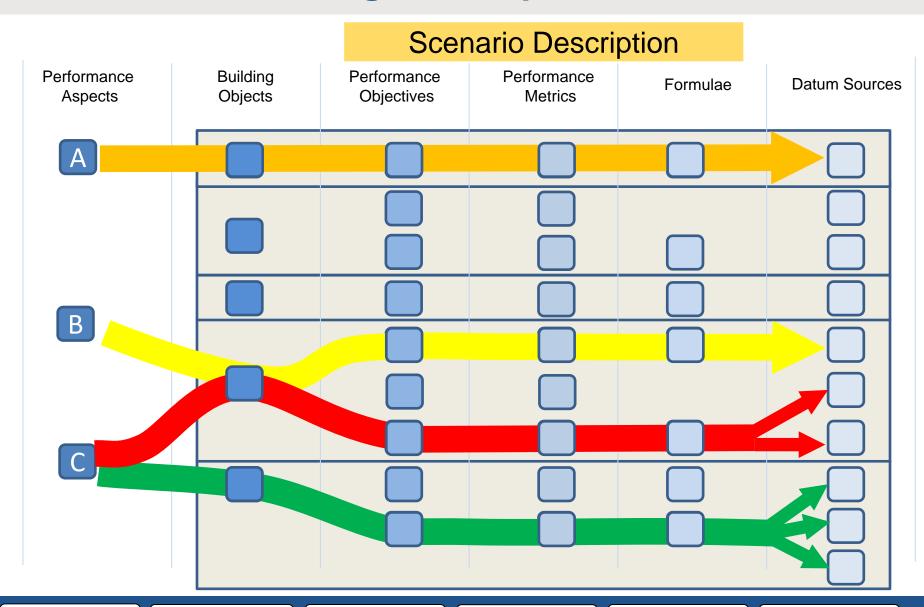
## Scenario Modelling: Class Representation



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## **Scenario Modelling: Concept**



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## **Scenario Modelling Structure**

## Example of Operation: Comfort V Energy Consumption

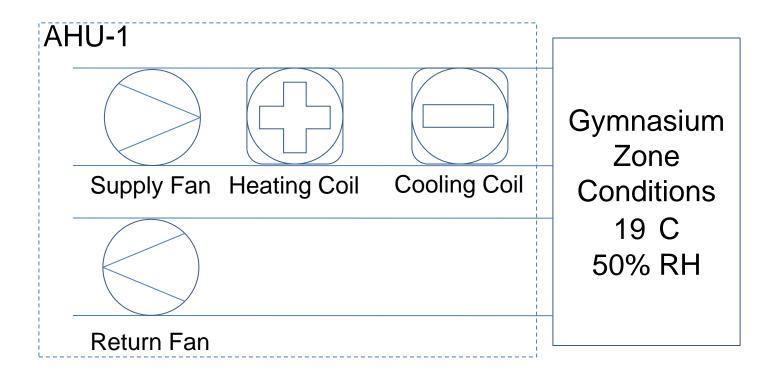
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Performance Aspects	Building Objects	Performance Objectives	Performance Metrics	Formulae	Datum Sources
					Measured  Datum 1: Zone Temperature ( C)
Building Function	Gymnasium Zone	Maintain Zone Temperature	Zone Temperature		Datum 1: Zone Temperature ( C)
					Simulated

## **Scenario Modelling Structure**

#### Example of Operation: Comfort V Energy Consumption Performance Building Performance Performance **Datum Sources** Formulae Objects **Objectives** Metrics **Aspects** Measured Datum 1: Water Flow Rate (kg/s) Datum 2: Water Supply Temperature ( Datum 3: Water Return Temperature ( C Energy **Chiller Energy** Datum 1\*Constant\* **Optimise Chiller** Chiller Operation Output (Datum3-Datum2) Consumption Datum 1: Water Flow Rate (kg/s) Datum 2: Water Supply Temperature ( C) Datum 3: Water Return Temperature ( Simulated Constant Value = Specific Heat Capacity of Output Fluid measured in J/Kg K

# Demonstration

## **Example 1: Full Fresh Air System**



## **Example 1: Summary of Important Information**

Reduction of Gymnasium Zone Temperature by 2 C				
Performance Aspects	Performance Aspects Building Objects			
Building Function	Gymnasium Zone	Change in Thermal Comfort		
Thermal Loads	Gymnasium Zone	Change in Thermal Loads		
		Change in Electricity Consumption		
Energy Consumption Chiller-1		Change in Cost of Operation		
System Performance	AHU 1	Change in Supply Temperature		
Legislation	Building	Change in CO <sub>2</sub> emissions		

## **Example 1: Building Function**

#### Reduction of Gymnasium Zone Temperature by 2 C Performance Building Performance Performance Fdmppatant Informationources **Aspects Objects Objectives** Metrics Measured Required Datum Streams Building Therma**Change in Maintain Thermal** Gymnasium Thermal Comfort Comfort Comfort Comfort Zone **Function** Required Datum Streams Simulated Measured Datum 1: Building Change in Maintain Zone 7one Gymnasium **Function Temperature Zone Temperature Temperature** Zone Zone Temperature (C) Simulated

## **Example 1: Thermal Loads**

## Reduction of Gymnasium Zone Temperature by 2 C

1100		ymmasium z	Lone rempe	rature by Z C
Performance	Building	Performance	Performance	Important Information
Aspects	Objects	Objectives	Metrics	
Thermal	Gymnasium	Minimise Zone	Zone Cooling	Change in Thermal Load
Loads	Zone	Cooling Load	Load	

## **Example 1: Building Function**

## Reduction of Gymnasium Zone Temperature by 2 C

Reduction of Gymnasium Zone Temperature by 2 C				
Performance Aspects	Building Objects	Performance Objectives	Performance Metrics	Important Information
Energy Consumption	Chiller-1	Minimise Chiller Energy Consumption	Chiller Electricity Consumption	Change in Chiller Electricity Consumption
Energy Consumption	Cooling Tower -1	Minimise Cooling Tower Loads	Cooling Tower Electricity Consumption	Change in Cooling Tower Electricity Consumption
Energy Consumption	AHU-1	Minimise Fans Energy Consumption	AHU Electricity Consumption	Change in Electricity Consumption

## **Example 1: System Performance**

## Reduction of Gymnasium Zone Temperature by 2 C

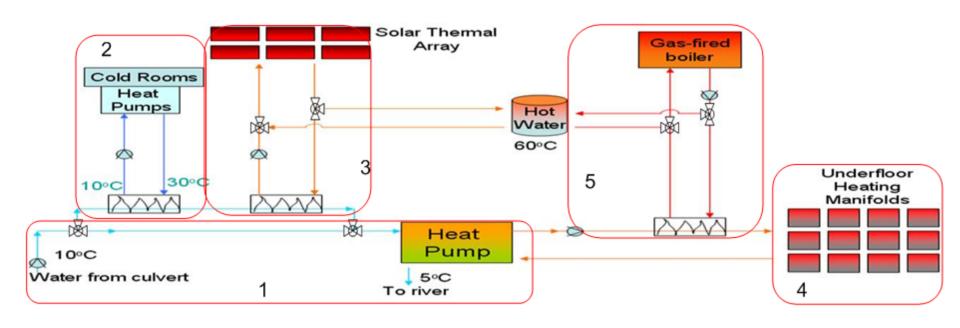
Reduction of Cymhasidin Zone Temperature by Z. C.					
Performance Aspects	Building Objects	Performance Objectives	Performance Metrics	Important Information	
System Performance	AHU-1	Maintain Intended Supply Temperature	Supply Temperature	Change in Supply Temperature	

## **Example 1: Legislation**

## Reduction of Gymnasium Zone Temperature by 2 C

Reduction of Cylinasian Zone Temperature by Z.C.					
Performance Aspects	Building Objects	Performance Objectives	Performance Metrics	Important Information	
Legislation	Building	Maintain CO2 emissions below agreed level	CO2 emissions	Change in CO2 emissions	

## **Example 2: Hybrid Heating and Cooling System**



**Proposed Solution** 21 Motivation Research Question **Demonstration** Conclusions Future Work

## **Example 2: Summary**

ERI Heating System Operation					
Performance Aspects	Building Objects	Important Information			
Building Function	ZG:05_Laboratory	No change in Thermal Comfort			
Thermal Loads		No change in Thermal Loads			
		Change in Electricity Consumption			
Energy Consumption	Heat Pump 1	Change in Cost of Operation			
System Performance	Heat Pump 1	Change in COP			
Legislation	Building	Change in CO2 emissions			

## Conclusion

## **Conclusions**

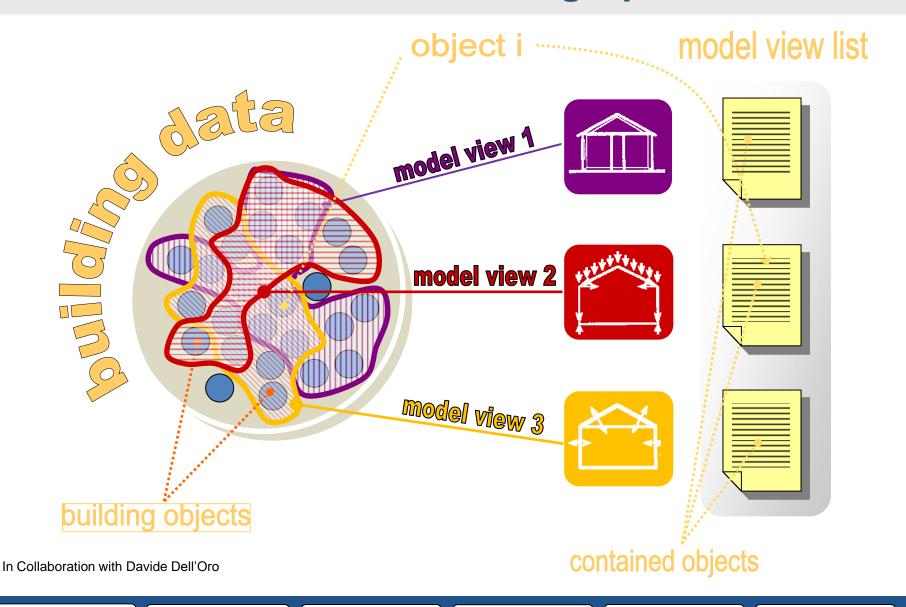
- Provides a standard technique that is applicable to all buildings
  - Eliminates ad-hoc and arbitrary data manipulation
  - Meaningfully relate actual operation back to design intent
- Benefits Fiscal Managers
  - Optimises building manager's time
  - Optimises system operation
  - Reduces energy consumption
  - Saves money



## **Future Work**

- Customise technique for other project stakeholders
  - Owners
  - Fiscal Decision Makers
  - Designers
  - Commissioning Consultants
  - Other
- Develop Scenario Templates for existing buildings
- BLC Database and Environment for Scenario Models
  - Accounts for data diversity
    - Simulation model output
    - Utility tariff

## **Future Work: MVD for Building Operation**



# **Any Questions?**